Can Afghanistan be a victim of the Malthusian population trap? what does the ARIMA approach tell us?

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Abstract

Using annual time series data on total population in Afghanistan from 1960 to 2017, we model and forecast total population over the next 3 decades using the Box – Jenkins ARIMA technique. Diagnostic tests such as the ADF tests show that Afghanistan annual total population is I (1). Based on the AIC, the study presents the ARIMA (1, 1, 2) model as the best model. The diagnostic tests further show that the presented model is stable and that its residuals are I (0). The results of the study reveal that total population in Afghanistan will continue to rise gradually in the next three decades and in 2050 Afghanistan's total population will be approximately 51 million people. In order to circumvent the chances of being a victim of the Malthusian population trap, 4 policy prescriptions have been suggested for consideration by the government of Afghanistan.

Key Words: Afghanistan, Forecasting, Population

JEL Codes: C53, Q56, R23

INTRODUCTION

As the 21st century began, the world's population was estimated to be almost 6.1 billion people (Tartiyus *et al*, 2015). Projections by the United Nations place the figure at more than 9.2 billion by the year 2050 before reaching a maximum of 11 billion by 2200. Over 90% of that population will inhabit the developing world (Todaro & Smith, 2006). The problem of population growth is basically not a problem of numbers but that of human welfare as it affects the provision of welfare and development. The consequences of rapidly growing population manifests heavily on species extinction, deforestation, desertification, climate change and the destruction of natural ecosystems on one hand; and unemployment, pressure on housing, transport traffic congestion, pollution and infrastructure security and stain on amenities (Dominic *et al*, 2016).

Afghanistan is a multiethnic society and its national anthem mentions 14 ethnic groups. It has a population of approximately 32 million. Approximately 63% of the population of the country is classified as youth i.e. under the age of 25 years (Bindu, 2017). Fertility in Afghanistan is estimated at an average of 5.1 children per woman. While still quite high – growing at 2.6% per year, the population is on pace to double every 26 years (Elizabeth, 2012). In Afghanistan, just like in any other part of the world, population modeling and forecasting is indeed vital for policy dialogue. Lack of recent and accurate population forecasts hinders development of an area in the sense that forecasts are essential for evidence-based planning, programme development, and project monitoring and evaluation. This study endeavors to model and forecast population of Afghanistan using the Box-Jenkins ARIMA technique.

LITERATURE REVIEW

Theoretical Literature Review: The Malthusian population trap in brief

The Malthusian population trap is a famous theory of the link between population growth and economic development. This theory states that human population grows geometrically while the means of subsistence grows arithmetically being subject to the law of diminishing returns. The popularity of the Malthusian population trap has convinced a plethora of development economists and policy makers that rapid population growth is a threat to economic development. This is mainly attributed to the proposition that rapid population growth results in tightening job markets, generating underemployment and discouraging labour force mobility across sectors. Therefore, the Malthusian population trap argues that rapid population growth is a real problem to any economy (Nyoni & Bonga, 2017).

Empirical Literature Review

Zakria & Muhammad (2009) forecasted population using Box-Jenkins ARIMA models in Pakistan, and relied on a data set ranging from 1951 to 2007; and found out that the ARIMA (1, 2, 0) model was the optimal model. Beg & Islam (2016) investigated population growth of Bangladesh using an autoregressive time trend model based on a data set ranging over 1965 – 2003 and discovered a downward population growth for Bangladesh for the extended period up to 2043. Ayele & Zewdie (2017) studied human population size and its pattern in Ethiopia using Box-Jenkins ARIMA models and employing annual data from 1961 to 2009 and concluded that the optimal model for modeling and forecasting population in Ethiopia was the ARIMA (2, 1, 2) model. In the case of Afghanistan, I will employ the Box-Jenkins ARIMA methodology for the data set ranging from 1960 to 2017.

MATERIALS & METHODS

ARIMA Models

ARIMA models are often considered as delivering more accurate forecasts then econometric techniques (Song *et al*, 2003b). ARIMA models outperform multivariate models in forecasting performance (du Preez & Witt, 2003). Overall performance of ARIMA models is superior to that of the naïve models and smoothing techniques (Goh & Law, 2002). ARIMA models were developed by Box and Jenkins in the 1970s and their approach of identification, estimation and diagnostics is based on the principle of parsimony (Asteriou & Hall, 2007). The general form of the ARIMA (p, d, q) can be represented by a backward shift operator as:

$$\emptyset(B)(1-B)^{d}POP_{t}=\theta(B)\mu_{t} \ldots \quad [1]$$

Where the autoregressive (AR) and moving average (MA) characteristic operators are:

$$\emptyset(B)=\left(1-\emptyset_{1}B-\emptyset_{2}B^{2}-\cdots-\emptyset_{p}B^{p}\right) \ldots \quad [2]$$

$$\theta(B)=\left(1-\theta_{1}B-\theta_{2}B^{2}-\cdots-\theta_{q}B^{q}\right) \ldots \quad [3]$$

and

$$(1-B)^{d}POP_{t}=\Delta^{d}POP_{t} \ldots \quad [4]$$

Where $\emptyset$ is the parameter estimate of the autoregressive component, θ is the parameter estimate of the moving average component, Δ is the difference operator, d is the difference, B is the backshift operator and μ_t is the disturbance term.

The Box – Jenkins Methodology

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018).

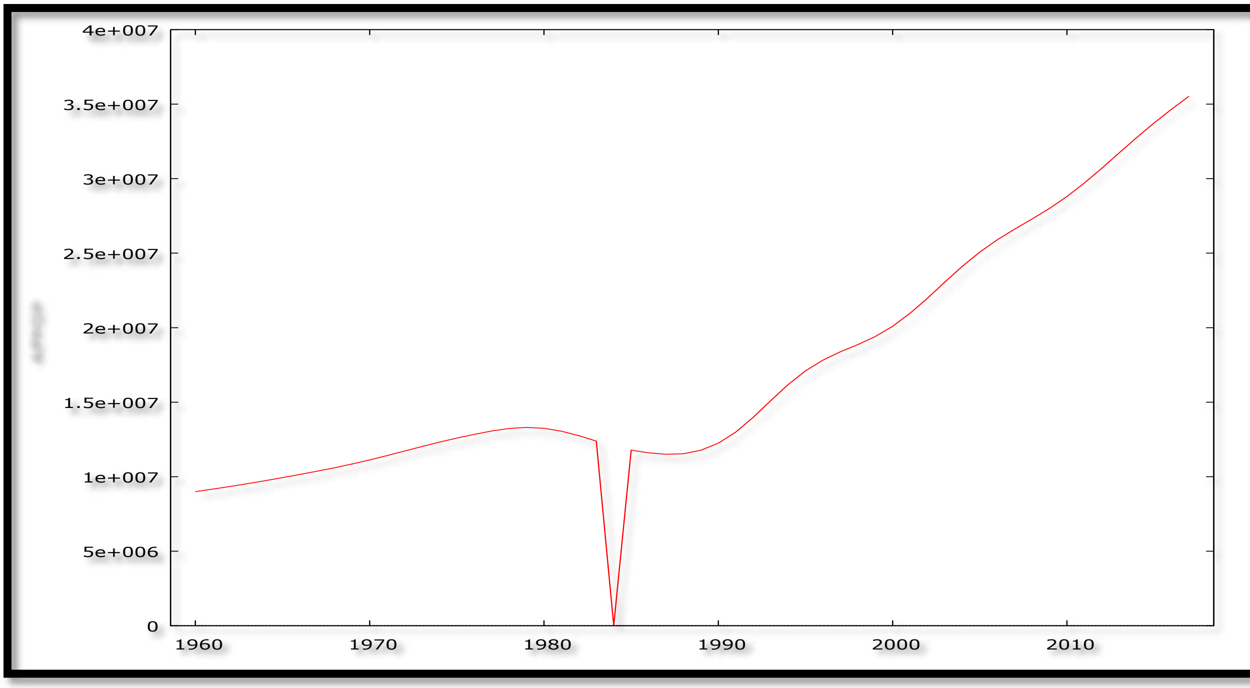
Data Collection

This study is based on 58 observations of annual total population in Afghanistan (AFPOP or simply POP). Pinney (2012) reiterated that population data in Afghanistan is extremely sensitive, among other reasons because it has been the basis for determining the composition of the Lower House of the National Assembly (the Wolesi Jirga). All the data used in this endeavor was gathered from the World Bank.

Diagnostic Tests & Model Evaluation

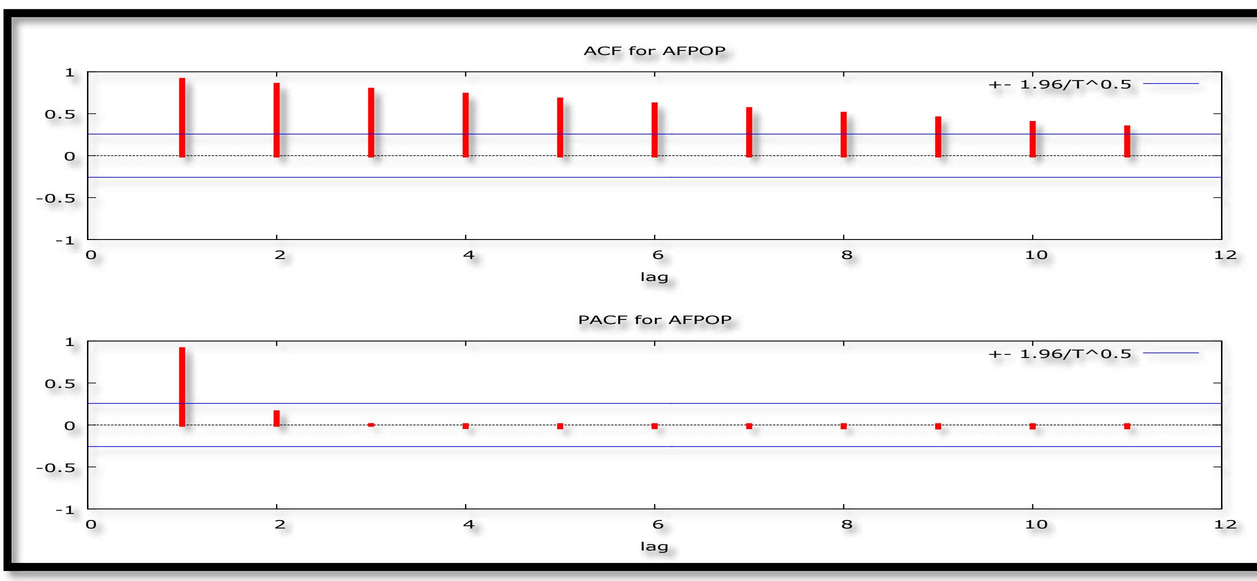
Stationarity Tests: Graphical Analysis

Figure 1



The Correlogram in Levels

Figure 2



The ADF Test

Table 1: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	0.922893	0.9952	-3.552666	@1%	Not stationary
			-2.914517	@5%	Not stationary

		-2.595033	@10%	Not stationary

Table 2: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-1.176654	0.9055	-4.130526	@1%	Not stationary
			-3.492149	@5%	Not stationary
			-3.3.174802	@10%	Not stationary

Table 3: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	2.526207	0.9968	-2.606911	@1%	Not stationary
			-1.946764	@5%	Not stationary
			-1.613062	@10%	Not stationary

Figures 1 and 2 and tables 1 – 3 indicate the is Afghanistan POP series is not an I (0) variable.

The Correlogram (at 1st Differences)

Figure 3

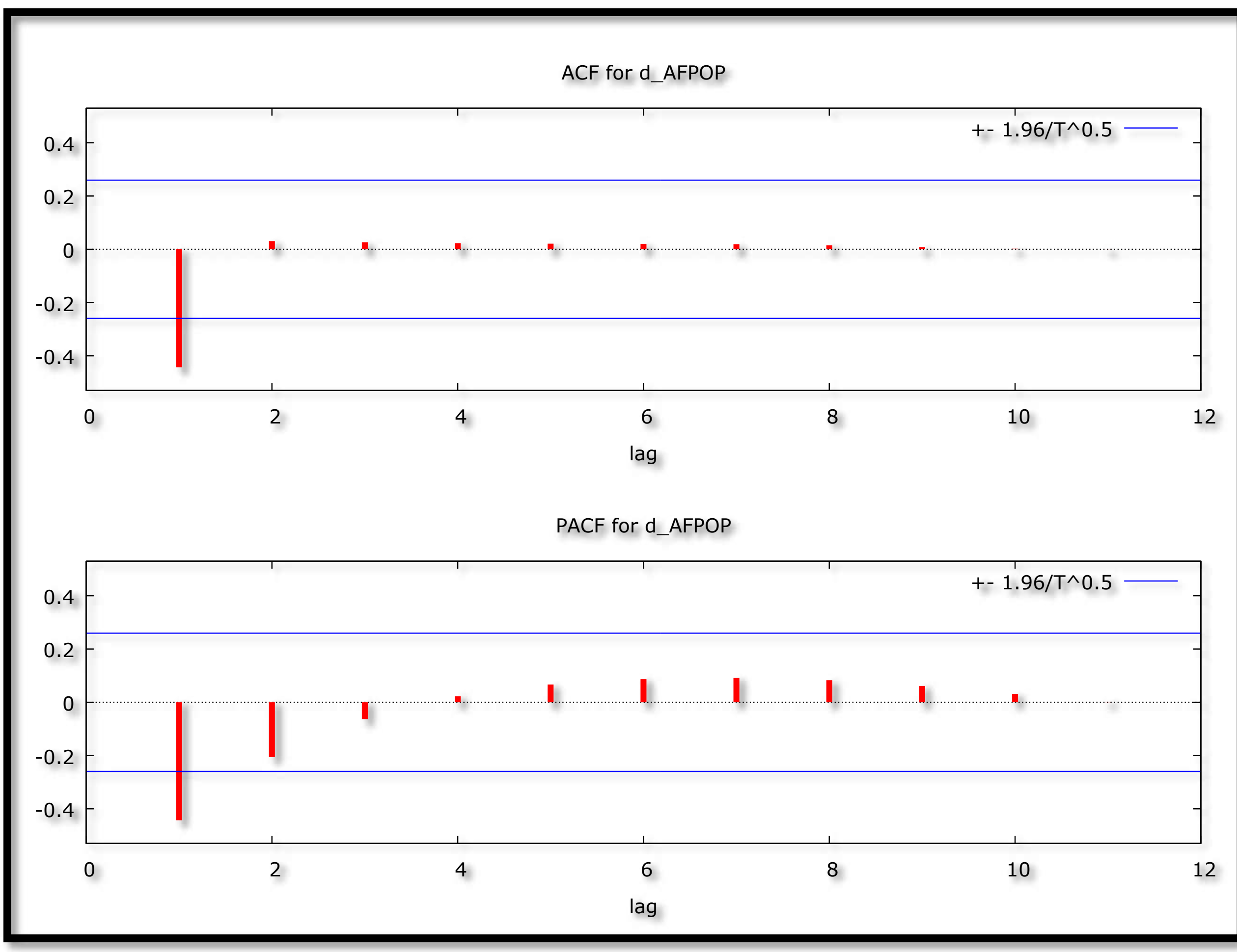


Table 4: 1st Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-11.82717	0.0000	-3.552666	@1%	Stationary
			-2.914517	@5%	Stationary
			-2.595033	@10%	Stationary

Table 5: 1st Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-12.13055	0.0000	-4.130526	@1%	Stationary
			-3.492149	@5%	Stationary
			-3.174802	@10%	Stationary

Table 6: 1st Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-11.15256	0.0000	-2.606911	@1%	Stationary
			-1.946764	@5%	Stationary
			-1.613062	@10%	Stationary

Figure 3 and tables 4 – 6, indicate that the Afghanistan POP series became stationary after taking first differences and thus it's an I (1) variable.

Evaluation of ARIMA models (without a constant)

Table 7

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 1, 1)	1830.554	0.56714	683650	1162900	2157500	1832.8
ARIMA (1, 1, 0)	1828.925	0.59905	637160	1120900	2164700	1827.9
ARIMA (0, 1, 1)	1829.421	0.62794	701890	1179200	2174700	1833.1
ARIMA (2, 1, 1)	1832.317	0.55739	687320	1176900	2152800	1833.7
ARIMA (3, 1, 1)	1828.861	0.46398	363210	902230	2039300	1868.1
ARIMA (4, 1, 1)	1829.915	0.4275	354710	897820	2019700	1878.7
ARIMA (5, 1, 1)	1831.606	0.41503	349250	896880	2013300	1883.4
ARIMA (6, 1, 1)	1833.503	0.41104	345990	895360	2011400	1885.1
ARIMA (2, 1, 0)	1830.379	0.55586	696120	1176900	2154000	1834.5
ARIMA (3, 1, 0)	1832.184	0.56472	658380	1162700	2150200	1831.4
ARIMA (1, 1, 2)	**1825.645**	0.42946	342950	890950	2014900	1884.1
ARIMA (1, 1, 3)	1827.602	0.41179	343690	892290	2013700	1884.6
ARIMA (2, 1, 2)	1827.606	0.41343	343540	892090	2013800	1884.6
ARIMA (3, 1, 3)	1831.422	0.41153	351040	899830	2010000	1883.4

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018). Theil's U must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018). The study will consider the minimum AIC in order to choose the best model for forecasting total population in Afghanistan. Therefore, the ARIMA (1, 1, 2) model is carefully selected.

Residual & Stability Tests

ADF Tests of the Residuals of the ARIMA (1, 1, 2)

Table 8: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-9.293361	0.0000	-3.555023	@1%	Stationary
			-2.915522	@5%	Stationary
			-2.595565	@10%	Stationary

Table 9: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-9.205612	0.0000	-4.133838	@1%	Stationary
			-3.493692	@5%	Stationary
			-3.175693	@10%	Stationary

Table 10: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-9.380318	0.0000	-2.607686	@1%	Stationary
			-1.946878	@5%	Stationary
			-1.612999	@10%	Stationary

The ADF tests of the residuals of the ARIMA (1, 1, 2) model show that the residuals are stationary.

FINDINGS

Descriptive Statistics

Table 11

Description	Statistic
Mean	17152000
Median	13153000
Minimum	12047
Maximum	35530000
Standard deviation	8150100
Skewness	0.73985
Excess kurtosis	-0.40915

As shown above, the mean is positive, i.e. 17152000. The wide gap between the minimum (i.e 12047) and the maximum (i.e. 35530000) is consistent with the observation that the Afghanistan POP series is gradually trending upwards over the period 1960 – 2017. The skewness is 0.73985 and the most vital characteristic is that it is positive, meaning that the Afghanistan POP series is positively skewed and non-symmetric. Excess kurtosis is -0.40915; showing that the Afghanistan POP series is not normally distributed.

Results Presentation[1]

Table 12

[1] *The *, ** and *** means significant at 10%, 5% and 1% levels of significance; respectively.*

ARIMA (1, 1, 2) Model:

$$\Delta POP_{t-1} = 0.968365\Delta POP_{t-1} - 1.48766\mu_{t-1} + 0.566147\mu_{t-2} \ldots\ldots\ldots\ldots\ldots\ldots[5]$$

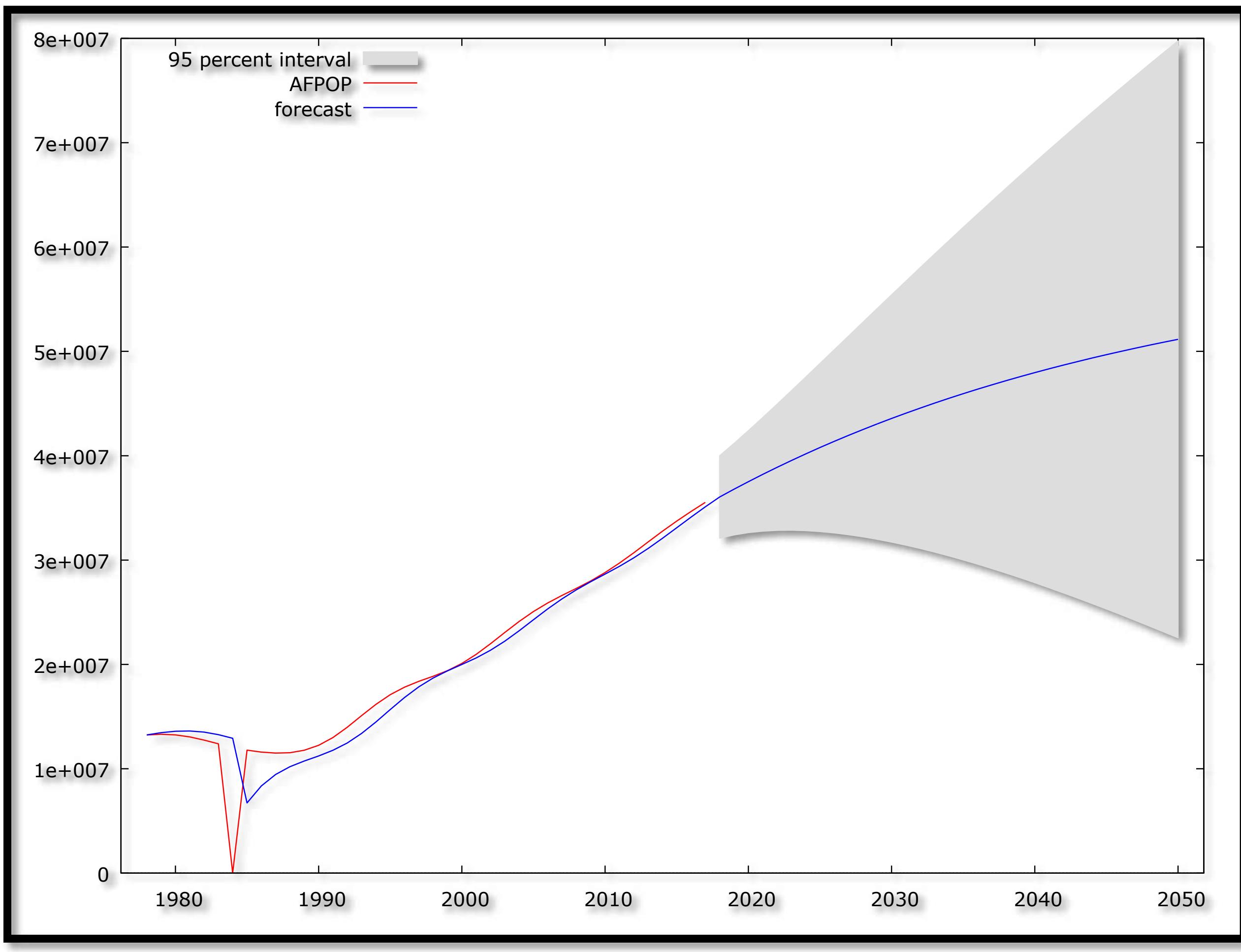
P: (0.0000) (0.0000) (0.0000)

S. E: (0.0724716) (0.124735) (0.112212)

Variable	Coefficient	Standard Error	z	p-value
AR (1)	0.968365	0.0724716	13.36	0.0000***
MA (2)	-1.48766	0.124735	-11.93	0.0000***
MA (2)	0.566147	0.112212	5.045	0.0000***

Forecast Graph

Figure 4



Predicted Total Population

Table 13

Year	Prediction	Std. Error	95% Confidence Interval
2018	36048446.44	2014685.061	32099736.28 - 39997156.60
2019	36792097.66	2235375.016	32410843.14 - 41173352.19
2020	37512223.33	2489589.818	32632716.95 - 42391729.71
2021	38209567.68	2772197.963	32776159.51 - 43642975.84
2022	38884851.40	3078633.661	32850840.30 - 44918862.50
2023	39538772.38	3405045.910	32865005.03 - 46212539.73
2024	40172006.45	3748260.349	32825551.16 - 47518461.74
2025	40785208.03	4105676.618	32738229.73 - 48832186.33
2026	41379010.86	4475158.407	32607861.55 - 50150160.16
2027	41954028.61	4854937.238	32438526.48 - 51469530.74
2028	42510855.57	5243534.816	32233716.17 - 52787994.96
2029	43050067.19	5639702.530	31996453.35 - 54103681.03
2030	43572220.74	6042374.978	31729383.41 - 55415058.08
2031	44077855.87	6450634.390	31434844.79 - 56720866.95
2032	44567495.13	6863683.271	31114923.11 - 58020067.14
2033	45041644.55	7280823.239	30771493.22 - 59311795.87
2034	45500794.16	7701438.497	30406252.07 - 60595336.24
2035	45945418.48	8124982.788	30020744.84 - 61870092.12
2036	46375977.02	8550968.998	29616385.75 - 63135568.29
2037	46792914.76	8978960.775	29194475.02 - 64391354.49
2038	47196662.59	9408565.705	28756212.66 - 65637112.51
2039	47587637.77	9839429.695	28302709.94 - 66872565.60
2040	47966244.38	10271232.309	27834998.98 - 68097489.78
2041	48332873.69	10703682.856	27354040.79 - 69311706.59
2042	48687904.61	11136517.085	26860732.21 - 70515077.01
2043	49031704.06	11569494.361	26355911.79 - 71707496.33

2044	49364627.34	12002395.246	25840364.93 - 72888889.76
2045	49687018.53	12435019.404	25314828.36 - 74059208.71
2046	49999210.81	12867183.771	24779994.04 - 75218427.59
2047	50301526.83	13298720.963	24236512.70 - 76366540.96
2048	50594279.02	13729477.863	23684996.88 - 77503561.16
2049	50877769.93	14159314.377	23126023.71 - 78629516.16
2050	51152292.55	14588102.325	22560137.39 - 79744447.71

Figure 4 (with a forecast range from 2018 – 2050) and table 13, clearly show that Afghanistan's total population is set to continue rising gradually, in the next 3 decades. With a 95% confidence interval of 22560137 to 79744448 and a projected total population of 51152293 by 2050, the chosen ARIMA (1, 1, 2) model is consistent with the population projections by the UN (2015) which forecasted that Afghanistan's population will be approximately 55955000 by 2050.

Policy Implications

i. The government of Afghanistan ought to invest more in infrastructural development in order to cater for the expected increase in total population.
ii. The predicted increase in total population in Afghanistan justifies the need for more and bigger companies to provide for the anticipated increase in demand for goods and services in Afghanistan.
iii. The government of Afghanistan should take action so as to improve health service delivery in the country in order to ensure a healthier society, particularly in light of such a likely increase in total population.
iv. The need for political stability cannot be undermined in Afghanistan. There is need to properly address the conflict between the Afghan government and the ISIS/Daesh. Without political stability, Afghanistan's anticipated increase in total population is arguably a threat to Afghanistan herself!

CONCLUSION

The study shows that the ARIMA (1, 1, 2) model is not only stable but also the most suitable model to forecast total population in Afghanistan for the next 3 decades. The model predicts that by 2050, Afghanistan's total population would be approximately, 51 million people. This is a warning signal to policy makers in Afghanistan, particularly with regards to infrastructural development, e.g schools and hospitals. These findings are vital for the government of Afghanistan, especially when it comes to long-term planning.

REFERENCES

[1] Asteriou, D. & Hall, S. G. (2007). Applied Econometrics: a modern approach, Revised Edition, *Palgrave MacMillan*, New York.

[2] Ayele, A. W & Zewdie, M. A (2017). Modeling and forecasting Ethiopian human population size and its pattern, *International Journal of Social Sciences, Arts and Humanities*, 4 (3): 71 – 82.

[3] Beg, A. B. M. R. A & Islam, M. R (2016). Forecasting and modeling population growth of Bangladesh, *American Journal of Mathematics and Statistics*, 6 (4): 190 – 195.

[4] Bindu, H (2017). Afghanistan – A country profile, *CAS*, Afghanistan.

[5] Dominic, A., Oluwatoyin, M. A., & Fagbeminiyi, F. F (2016). The determinants of population growth in Nigeria: a co-integration approach, *The International Journal of Humanities and Social Studies*, 4 (11): 38 – 44.

[6] Du Preez, J. & Witt, S. F. (2003). Univariate and multivariate time series forecasting: An application to tourism demand, *International Journal of Forecasting*, 19: 435 – 451.

[7] Elizabeth, L. M (2012). Afghanistan, Against the Odds: A Demographic Surprise, *Environmental Change and Security Program Report*, Vol. 14 – Issue 1, Washington DC.

[8] Goh, C. & Law, R. (2002). Modeling and forecasting tourism demand for arrivals with stochastic non-stationary seasonality and intervention, *Tourism Management*, 23: 499 – 510.

[9] Nyoni, T & Bonga, W. G (2017). Population growth in Zimbabwe: A Threat to Economic Development? *DRJ – Journal of Economics and Finance*, 2 (6): 29 – 39.

[10] Nyoni, T (2018). Modeling and Forecasting Inflation in Kenya: Recent Insights from ARIMA and GARCH analysis, *Dimorian Review*, 5 (6): 16 – 40.

[11] Nyoni, T (2018). Modeling and Forecasting Naira / USD Exchange Rate in Nigeria: a Box – Jenkins ARIMA approach, *University of Munich Library – Munich Personal RePEc Archive (MPRA)*, Paper No. 88622.

[12] Nyoni, T. (2018). Box – Jenkins ARIMA Approach to Predicting net FDI inflows in Zimbabwe, *Munich University Library – Munich Personal RePEc Archive (MPRA)*, Paper No. 87737.

[13] Pinney, A (2012). An Afghan Population Estimation, *Afghan Analysts Network (AAN)*.

[14] Song, H., Witt, S. F. & Jensen, T. C. (2003b). Tourism forecasting: accuracy of alternative econometric models, *International Journal of Forecasting*, 19: 123 – 141.

[15] Tartiyus, E. H., Dauda, T. M., & Peter, A (2015). Impact of population growth on economic growth in Nigeria, *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, 20 (4): 115 – 123.

[16] Todaro, M & Smith, S (2006). Economic Development, 9th Edition, *Vrinda* Publications, New Delhi.

[17] United Nations (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables, *Department of Economic and Social Affairs*, Population Division, Working Paper No. ESA/P/WP/241.

[18] Zakria, M & Muhammad, F (2009). Forecasting the population of Pakistan using ARIMA models, *Pakistan Journal of Agricultural Sciences*, 46 (3): 214 – 223.